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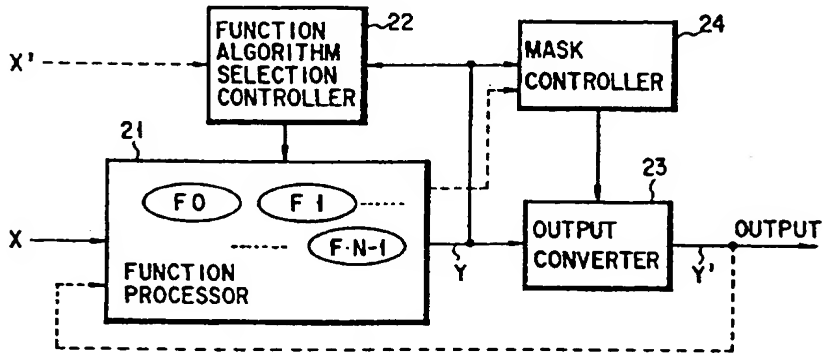
(54) Processing module with function selection

(57) A data processing module comprises a processor 21 for storing a plurality of function algorithms F0, F1 .... Fn and for executing a designated one of them; and a controller 22 for selecting one of the algorithms to be subsequently executed on the basis of all or part of a processing result Y. The selection may be deterministic or statistical and involve comparison of the result with externally-input data. The processing result may be converted, 23, by masking to provide an output Y'. The module may be one of a series used in compressing/encrypting data blocks.



F I G. 6

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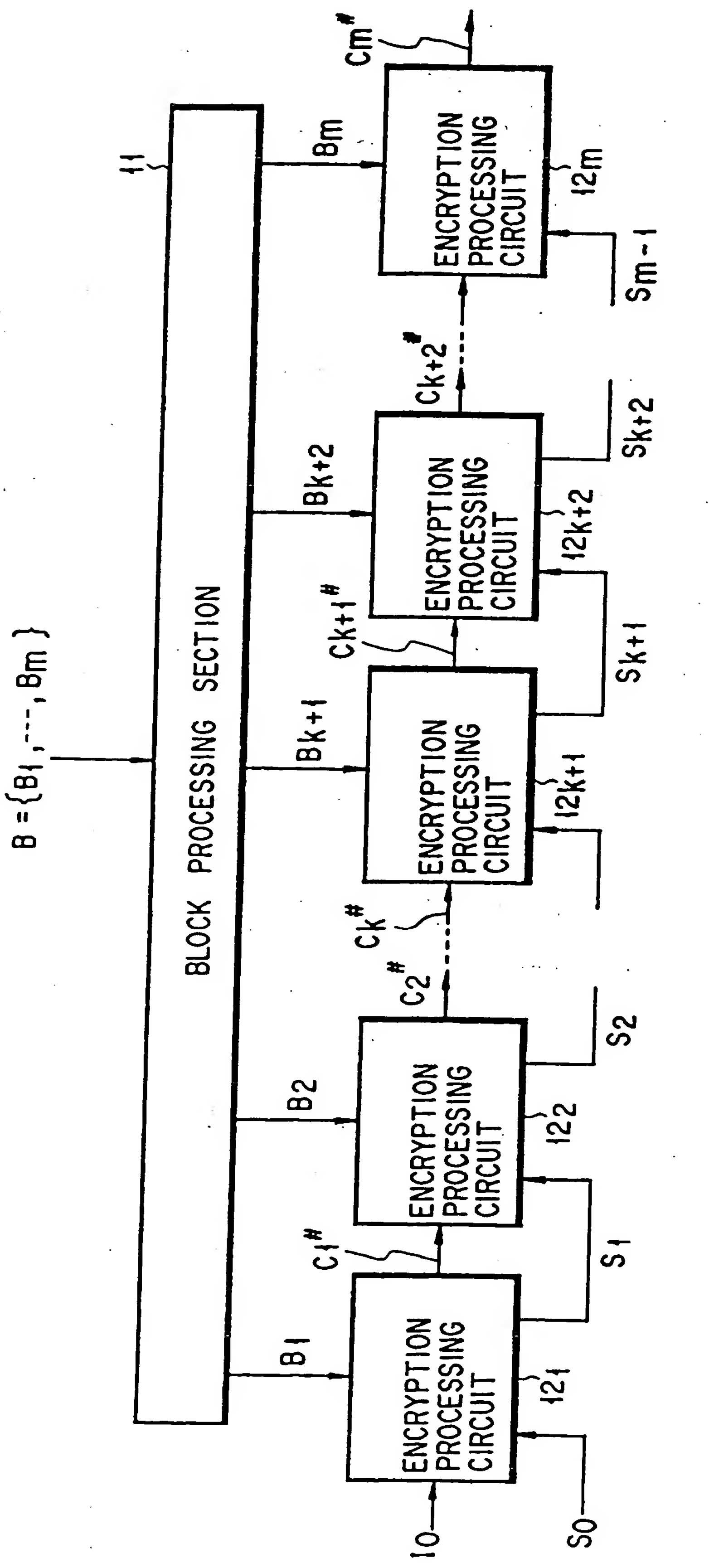
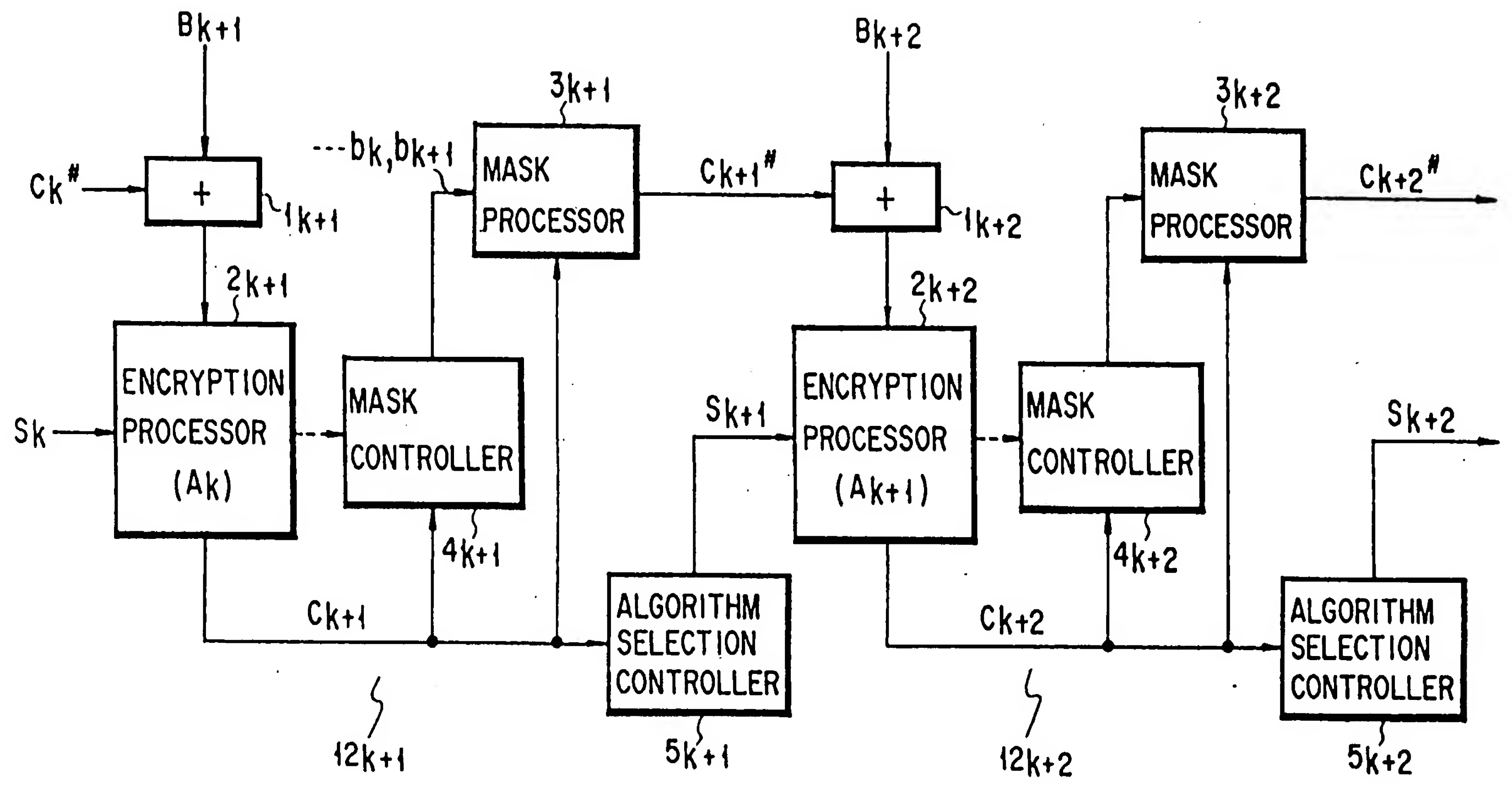

B = {B1, ---, Bm}
11
BLOCK PROCESSING SECTION
B1
B2
Bk+1
Bk+2
Bm
ENCRYPTION PROCESSING CIRCUIT
121
122
12k+1
12k+2
12m
10
S0
S1
S2
Sk+1
Sk+2
Sm-1
C1#
C2#
Ck#
Ck+1#
Ck+2#
Cm#

FIG. 1


Bk+1
Ck#
+
1k+1
2k+1
ENCRYPTION PROCESSOR (Ak)
Sk
---bk,bk+1
MASK PROCESSOR
3k+1
MASK CONTROLLER
4k+1
Ck+1
12k+1
Ck+1#
ALGORITHM SELECTION CONTROLLER
5k+1
Sk+1
Bk+2
+
1k+2
2k+2
ENCRYPTION PROCESSOR (Ak+1)
MASK CONTROLLER
4k+2
Ck+2
12k+2
MASK PROCESSOR
3k+2
Ck+2#
Sk+2
ALGORITHM SELECTION CONTROLLER
5k+2

F I G. 2

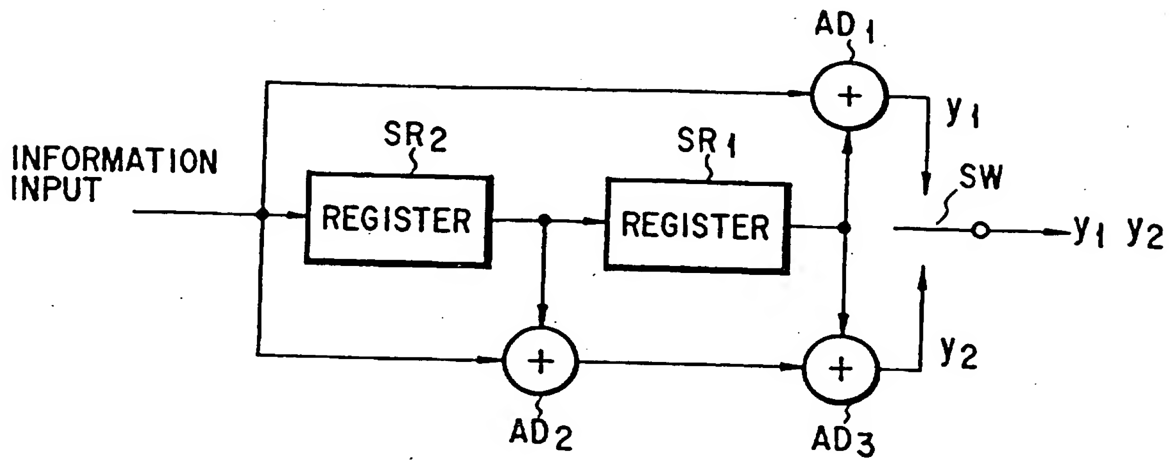

INFORMATION INPUT
SR2
REGISTER
SR1
REGISTER
AD1
AD2
AD3
y1
y2
SW
y1 y2

FIG. 3

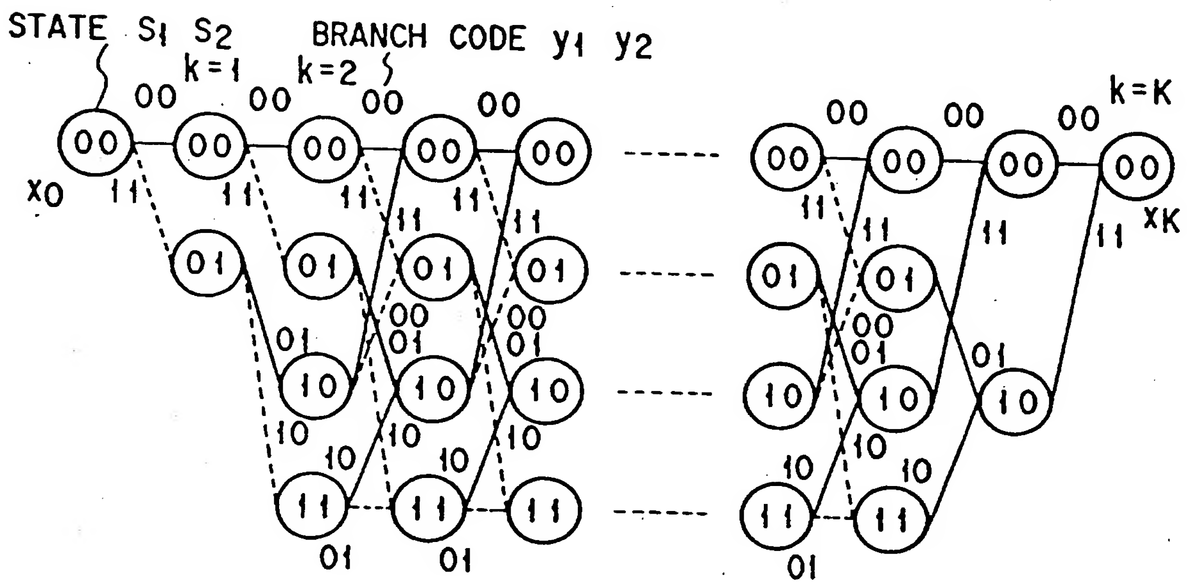

STATE S1 S2
BRANCH CODE y1 y2
k=1
k=2
k=K
X0
XK
00
01
10
11

FIG. 4

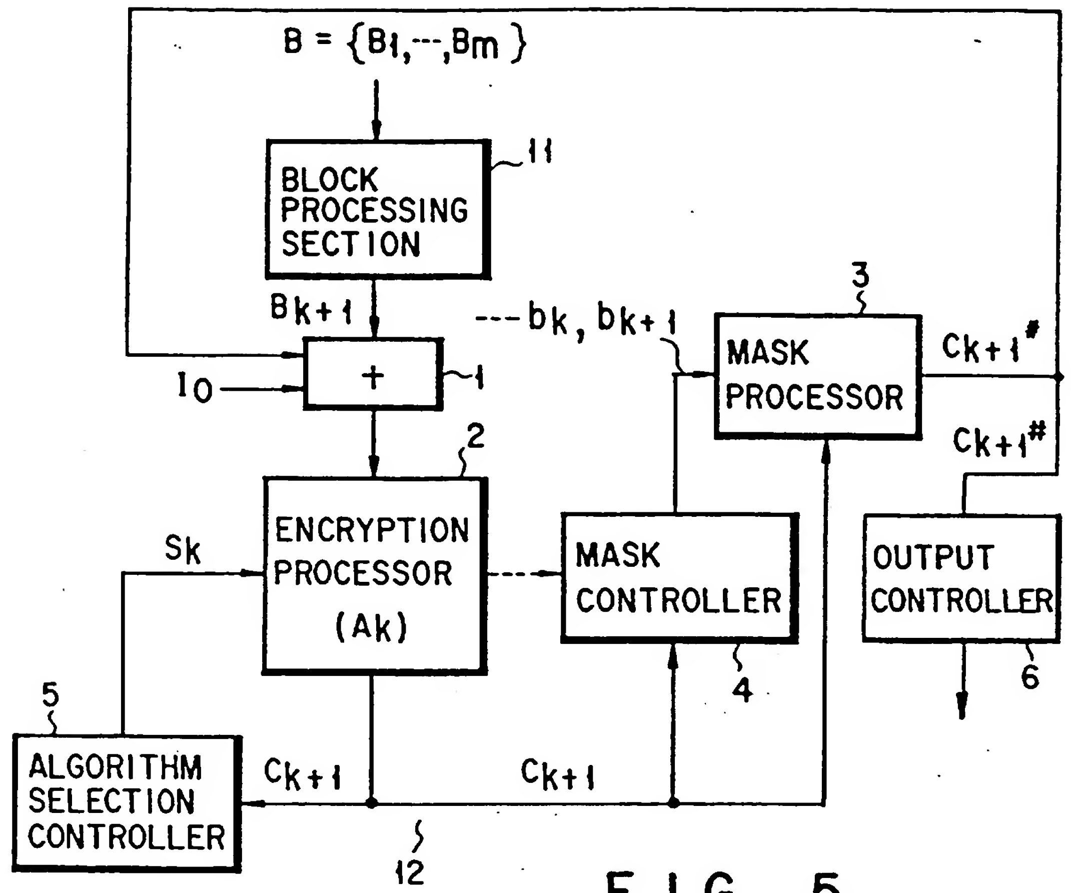

B = {B1,---,Bm}
BLOCK PROCESSING SECTION
11
Bk+1
+
1
I0
---bk, bk+1
MASK PROCESSOR
3
Ck+1#
Ck+1#
2
ENCRYPTION PROCESSOR (Ak)
Sk
MASK CONTROLLER
4
OUTPUT CONTROLLER
6
5
ALGORITHM SELECTION CONTROLLER
Ck+1
Ck+1
12

FIG. 5

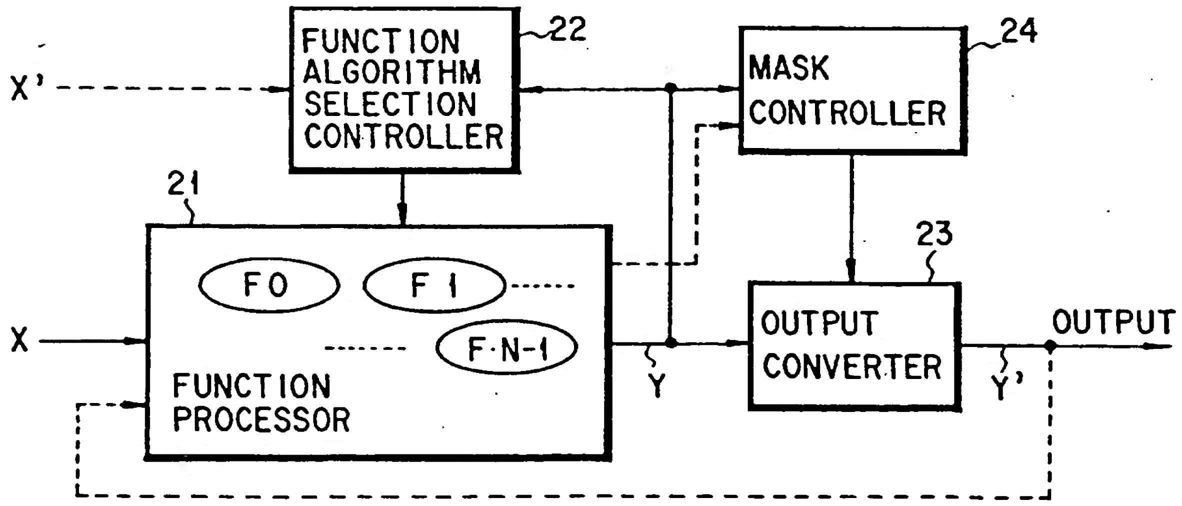

X'
FUNCTION ALGORITHM SELECTION CONTROLLER
22
MASK CONTROLLER
24
21
23
F0
F1
F·N-1
X
FUNCTION PROCESSOR
Y
OUTPUT CONVERTER
Y'
OUTPUT

FIG. 6

"DATA PROCESSING APPARATUS"

The present invention relates to a data processing apparatus for compressing/encrypting message data by use of a plurality of function algorithms. The present invention also relates to a modularization technique for the data processing apparatus.

In recent years, a data compression type encryption processing function (a hash function), which is applicable to the compression/encryption processing of message data, has attracted the attention of those skilled in the art. To put this function into practice, a method that utilizes, for example, the CBC (cipher block chaining) mode of the DES (data encryption standard) has been proposed.

According to this method, message data subjected to data hashing is divided into data blocks of appropriate size (e.g., L bits) as follows:

$\{B_i\}$ $(i = 1 \text{ to } m)$

The encryption processing for the (k+1)th data block (k = 0 to m-1) is defined as follows:

$C_{k+1} = FK(C_k + B_{k+1})$

It is assumed that FK represents a block encryption processing function using an encryption key K (fixed). It is also assumed that where k = 0, an initial vector I_0 is given to C_0. In this case, the hash value is defined by the processing result C_m obtained in the final stage of the processing.

However, the data compression/encryption processing system utilizing the CBC mode has problems in that once the encryption key K is decoded, two different message data items having the same hash value may be easily produced.

Let it be assumed that the data blocks of the two different message data items M and M' are expressed by:

$M = \{B_i\}$

$M' = \{B_i'\}$

where i = 1 to m. If, in this case, the condition expressed by

$C_{m-1} + B_m = C_{m-1}' + B_m'$

is satisfied, the hash values of M and M' become equal to each other though the message data items have been processed in different ways.

In other words, "$C_{m-1} + B_m$" can be presumed based on hash value C_m if the encryption key K is decoded. Hence, M', which has the same hash value as M, can be obtained by performing calculation, with a block group $\{B_i'\}$ (i = 1 to m-1) appropriately determined, and by determining the final block B_m' to satisfy the condition formula. This means that data collision may easily occur in the encryption processing method which is based on the hash function utilizing the CBC mode.

An encryption LSI (large scale integration circuit) is known as a function processing module which is used to execute the function processing (e.g., encryption processing) of data, for the data security purpose. In the prior art, the function processing module of this type supports only one function algorithm. Even if it supports a plurality of function algorithms, one of them is selected for use, in response to an external switching control signal. Therefore, when a data processing apparatus of this type is fabricated as a module, it is necessary to ensure very reliable data security.

As has been described, the use of the hash function utilizing, for example, the conventional CBC mode results in an increase in the possibility of the occurrence of data collision. Therefore, a data processing apparatus adopting the hash function has to be so designed as to avoid the data collision, for ensuring data security. Where the data processing apparatus of this type is fabricated as a module, consideration has to be given to ensure more reliable data security.

The present invention has to be developed to solve the problems mentioned above, and the first object of the present invention is to provide a data processing apparatus which prevents data collision from occurring when data is subjected to compression/encryption processing, and which ensures reliable data security. The second object of the present invention is to provide a modularization technique which ensures the secrecy of data when the data processing apparatus of this type is fabricated as a module.

According to the present invention, there is provided a data processing apparatus comprising:

a block processing section (11) for dividing message data (B) into a plurality of blocks, so as to obtain a plurality of data blocks (B_i (i = 1 to m)); and

a plurality of data conversion processing sections (12_i) which are provided in correspondence to the data blocks (B_i) and each of which stores a plurality of data conversion algorithms therein, a first one of the data conversion processing sections selecting one (A_{i-1}) of the data conversion algorithms in response to an initial selection control signal (S_0) and each of remaining ones of the data conversion processing sections selecting one (A_{i-1}) of the data conversion algorithms in response to a selection control signal (S_{i-1}) supplied from a preceding data conversion processing section (B_{i-1}), each of the data conversion processing sections (12_i) performing data conversion processing with respect to the corresponding data block (B_i) on the basis of the selected data conversion algorithm and generating a selection control signal used for processing a next data block (B_{i+1}) on the basis of the data conversion processing.

This invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a block circuit diagram showing a data processing apparatus according to the first embodiment of the present invention;

Fig. 2 is a block circuit diagram showing the configuration of a compression/encryption circuit employed in the first embodiment;

Fig. 3 is a block circuit diagram showing the configuration of a convolutional encoder which realizes the encryption algorithm determination method used in the first embodiment;

Fig. 4 is a trellis diagram corresponding to the operation of the convolutional encoder shown in Fig. 3;

Fig. 5 is a block circuit diagram showing a data processing apparatus according to the second embodiment of the present invention, the data processing apparatus being obtained by simplifying that of the first embodiment; and

Fig. 6 is a block circuit diagram showing the configuration of a general-purpose data processing module according to the third embodiment, the data processing module being applicable not only to the data processing performed by the apparatuses shown in Figs. 1 and 5 but also to data processing of other kinds.

The first embodiment of the present invention will now be described with reference to the accompanying drawings. The embodiment will be described, referring to the case where message data is subjected to compression/encryption processing by use of a hash function utilizing an improved and generalized CBC mode.

Fig. 1 shows the data processing apparatus employed in the embodiment. Referring to Fig. 1, a block processing section 11 divides input message data B into a plurality of blocks, and the resultant data blocks B_i ($i = 1, 2, \ldots, k+1, k+2, \ldots, m$) are output in parallel at appropriate time intervals. Each data block B_i is supplied to the corresponding one of encryption processing circuits 12_i.

The encryption processing circuits 12_i are of the same configuration, and an initial parameter I_0 (which can be used as a key) is determined for the first one 12_1 of encryption processing circuits 12_i. Each of the remaining encryption processing circuits 12_i receives data block B_i, and encrypts it on the basis of the processing result $C_{i-1}^{\#}$ (when i=1, $C_0^{\#} = I_0$) of the preceding processing circuit. The result of processing of the final processing circuit 12_m is the compressed and encrypted data of message data B.

Fig. 2 shows the circuit configurations of the (k+1)th and (k+2)th ones of the encryption processing circuits 12_i mentioned above. Referring to Fig. 2, the (k+1)th data block is supplied to an adder 1_{k+1}. By this adder, the kth processing result $C_k^{\#}$ (when $k=0$, $C_0^{\#}=I_0$) is added to the data block B_{k+1}. The result of this addition is supplied to an encryption processor 2_{k+1}. The encryption processor 2_{k+1} selects one of pre-stored N encryption function algorithms (hereinafter referred to as "encryption algorithms" or simply as "algorithms") A_0 to A_{N-1}, in response to a selection signal S_k supplied from a kth algorithm selection controller, and encrypts the addition result of the adder 1_{k+1} by use of the selected algorithm.

The processing result C_{k+1} of the encryption processor 2_{k+1} is supplied to both a mask processor 3_{k+1} and a mask controller 4_{k+1}.

Upon reception of the processing result C_{k+1}, the mask controller 4_{k+1} identifies the history of the encryption algorithm executed by the encryption processor 2_{k+1} and stores the data obtained by the identification. Then, the mask controller 4_{k+1} determines a control value $(\ldots, b_k, b_{k+1})$ dependent on the entirety or part of the encryption algorithm, and supplies the determined control value to the mask processor 3_{k+1}.

Since the history of the encryption algorithm executed by the encryption processor 2_{k+1} can be stored as data in the encryption processor 2_{k+1}, the mask controller 4_{k+1} may be supplied with the history data directly from the encryption processor 2_{k+1}.

The mask processor 3_{k+1} performs mask processing with respect to the processing result C_{k+1} of the encryption processor 2_{k+1}, such that the processing result C_{k+1} cannot be read or presumed afterwards. To be more specific, the entirety or part of the processing result C_{k+1} is replaced with other values on the basis of the control value (..., b_k, b_{k+1}) supplied from the mask controller 4_{k+1}. The result $C_{k+1}^{\#}$ of the mask processing is supplied to the (k+2)th adder 1_{k+2}.

The processing result C_{k+1} of the encryption processor 2_{k+1} is also supplied to an algorithm selection controller 5_{k+1}. By this controller 5_{k+1}, an encryption algorithm to be executed by a (k+2)th encryption processor 2_{k+2} is determined, using a statistical method which is dependent on both the encryption algorithm A_k executed by the encryption processor 2_{k+1} and the values of the entirety or part of the processing result C_{k+1} obtained by the execution of the encryption algorithm A_k. A selection signal S_{k+1} representing the determined encryption algorithm is supplied to the (k+2)th encryption processor 2_{k+2}.

Just like the (k+1)th encryption processing circuit, the (k+2)th encryption processing circuit for performing encryption of data block B_{k+2} is made up of an adder 1_{k+2}, an encryption processor 2_{k+2}, a mask processor 3_{k+2}, a mask controller 4_{k+2}, and an algorithm selection controller 5_{k+2}. The operations of these structural components are similar to those of the structural components of the (k+1)th encryption processing circuit.

The configuration and operation of each of the other encryption processing circuits (namely, the first through ith processing circuits and (k+3)th through m-th processing circuits) are similar to those mentioned above. Therefore, the configurations of the other encryption processing circuits are not shown in the drawings, and reference to the operations of them will be omitted herein. It should be noted that since each encryption processing circuit processes the data output from its preceding encryption processing circuit, the block processing section 11 has to supply data blocks B_i to the respective encryption processing circuits with appropriate time delays.

The reasons why data collision can be prevented in the above-mentioned data processing apparatus will now be explained.

The compression/encryption procedures of message data are defined by the following formulas:

$$C_{k+1} = A_k(C_k^{\#} + B_{k+1}) \quad \dots (1)$$

$$A_{k+1} = g(A_k, [C_{k+1}]_n) \quad \dots (2)$$

$$C_{k+1}^{\#} = C_{k+1} + [b_{k-r+2} \cdots b_k \; b_{k+1}] \quad \dots (3)$$

where $0 \leq k \leq (m-1)$.

Assuming that $1 \leq i \leq (n+\alpha)$ and $r(n+\alpha)=L$, the following formulas are obtained:

$$[b_{k-r+2} \cdots b_k \; b_{k+1}]$$
$$= [b_{k-r+2}(i) \cdots b_k(i) \; b_{k+1}(i)] \quad \dots (4)$$

$$b_{k+1}(i) = \beta(\xi_{k+1} : A_k \rightarrow A_{k+1}) \quad \dots (5)$$

When k=0 in these formulas, A_0 denotes an arbitrarily-designated initial algorithm, and $C_0\#$ denotes an appropriate initial vector (initial parameter) I_0.

What is meant by each of the above formulas (1)-(5) will be explained.

Where A_k denotes the encryption algorithm executed by the (k+1)th encryption processing circuit, encrypted data C_{k+1} is derived from the processing result $C_k\#$ of the kth encryption processing circuit and the present data block B_{k+1} by use of the encryption algorithm A_k. (formula (1))

Then, an encryption algorithm A_{k+1} to be executed in the next encryption processing circuit (i.e., the (k+2)th processing circuit) is determined based on both n bits $[C_{k+1}]_n$ included in the encrypted data C_{k+1} (e.g., lower n bits of the encrypted data) and the encryption algorithm A_k presently executed. (formula (2))

The encryption algorithm A_{k+1} to be executed in the next encryption processing circuit can be determined in various methods. One of the methods is a method wherein the n bits of the encrypted data C_{k+1} and the present encryption algorithm A_k are used such that the temporal changes in the encryption algorithm form a finite-state discrete-time Markovian process.

To realize this method, the use of a trellis diagram of the convolutional codes of an encoding rate of $n/(n+\alpha)$ is effective. The trellis diagram is one of the representations of convolutional codes and is a kind of state transition diagram. The trellis diagram is featured in that all states are shown in relation to time.

Fig. 3 is a block circuit diagram showing the configuration of a general convolutional encoder, and Fig. 4 is a trellis diagram corresponding to the operation of the convolutional encoder. In the convolutional encoder shown in Figs. 3 and 4, an encoded output of 2 bits is produced in response to an information input of 1 bit, so that the encoding rate is 1/2.

Referring to Fig. 3, a 1-bit information input is sequentially shifted by 1-bit shift registers SR_1 and SR_2. The 1-bit information input is added to the output of shift register SR_1 by an adder AD_1, to thereby obtain a signal y_1. Also, the 1-bit information input is added to the output of shift register SR_2 by an adder AD_2, and the resultant signal is added to the output of register SR_1 by an adder AD_3, to thereby obtain a signal y_2. Signals y_1 and y_2 are alternately output by means of a switch SW.

In Fig. 4, the states of registers SR_1 and SR_2 are shown in the vertical direction, and time k is shown in the horizontal direction. When information bit "1" is input in the state where k=0 and the contents of registers SR_1 and SR_2 are (00), the contents of registers SR_1 and SR_2 become (01) when k=1. This state transition is indicated by the broken lines.

In Fig. 4, an encoder output (11) is assigned to line segments corresponding to the state transitions. The line segments are generally referred to as "branches", and the encoder output (11) is often referred to as "branch codes".

When information bit "0" is input, the contents of registers SR_1 and SR_2 become (00). This state transition is indicated by the solid lines. The related encoder outputs <00> are assigned to the corresponding transition branches.

In the trellis diagram representation, a series of branches are referred to as a "path", and each of the paths extending from the left side to the right side of the trellis diagram corresponds to a code.

The convolutional codes mentioned above and the trellis diagram thereof are described in detail in A.J. Viterbi, Convolutional Codes and Their Performance in Communication Systems, IEEE Trans. Commun. Technol, vol. COM-19, No. 5, pp. 751-772, 1971.

When state A_k in the trellis diagram subsequently changes to new state A_{k+1} in response to input of n bits (information bits), a new branch code represented by

$$b_{k+1}(i) \quad (1 \leq i \leq n+\alpha)$$

is produced. (formula (5)) By use of the past history of the branch codes including this new branch code (formula (4)), the entirety (or part) of the values of the history is replaced with other values dependent on the entirety (or part) of the history of the algorithms, thereby concealing the value of C_{k+1}. The result obtained thereby is expressed as $C_{k+1}{}^{\#}$ (formula (3)).

A description will be given of the conditions under which data collision occurs. In view of the definitions, it is understood that data collision occurs when the hash values $C_m{}^{\#}$ and $(C_m')^{\#}$ of two different message data items M and M' coincide with each other. In the following, therefore, a description will be given of the condition under which the hash values coincide with each other.

The hash values $C_m{}^{\#}$ and $(C_m')^{\#}$ of the different message data items M and M' are represented by:

$$C_m{}^{\#} = C_m + [b_{m-r+1}\ b_{m-r+2}\ \cdots\ b_m]$$

$$(C_m')^{\#} = C_m' + [b_{m-r+1}'\ b_{m-r+2}'\ \cdots\ b_m']$$

Hence, the two hash values become equal to each other when the following two conditions are satisfied:

$$C_m = C_m'$$

$$[b_{m-r+1}\ b_{m-r+2}\ \cdots\ b_m] = [b_{m-r+1}'\ b_{m-r+2}'\ \cdots\ b_m']$$

With the latter relationships in mind, the following conditions are initially determined:

$$A_{m-r} = A_{m-r}'$$

$$C_{m-r}{}^{\#} + B_{m-r+1} = (C_{m-r}')^{\#} + B_{m-r+1}' \quad \cdots (6)$$

In this case, the following formula is obtained because of the assumption:

$$C_{m-r+1} = A_{m-r}\ (C_{m-r}{}^{\#} + B_{m-r+1})$$
$$= A_{m-r}'\ \{(C_{m-r}')^{\#} + B_{m-r+1}'\}$$
$$= C_{m-r+1}'$$

Hence, the following formula is satisfied:

$$[C_{m-r+1}]n = [C_{m-r+1}']n$$

Accordingly, the following two formulas are derived:

$$A_{m-r+1} = A_{m-r+1}'$$
$$b_{m-r+1} = b_{m-r+1}'$$

Next, let it be assumed that the condition represented below is satisfied:

$$C_{m-r+1}{}^{\#} + B_{m-r+2} = (C_{m-r+1}')^{\#} + B_{m-r+2}' \quad \ldots (7)$$

In this case, the following formula is obtained:

$$C_{m-r+2} = A_{m-r+1}\ (C_{m-r+1}{}^{\#} + B_{m-r+2})$$
$$= A_{m-r+1}'\ \{(C_{m-r+1}')^{\#} + B_{m-r+2}'\}$$
$$= C_{m-r+2}'$$

Hence, the following formula is satisfied:

$$[C_{m-r+2}]n = [C_{m-r+2}']n$$

Accordingly, the following two formulas are derived:

$$A_{m-r+2} = A_{m-r+2}'$$
$$B_{m-r+2} = b_{m-r+2}'$$

After similar procedures are repeated, the condition represented below is assumed:

$$C_{m-1}{}^{\#} + B_m = (C_{m-1}')^{\#} + B_m' \quad \ldots (8)$$

In this case, the following formula is obtained:

$$C_m = A_{m-1} (C_{m-1}^{\#} + B_m)$$
$$= A_{m-1}' \{(C_{m-1}')^{\#} + B_m'\}$$
$$= C_m'$$

Hence, the following formula is satisfied:

$$[C_m]_n = [C_m']_n$$

Accordingly, the following two formulas are derived:

$$A_m = A_m'$$
$$b_m = b_m'$$

At the time, the condition represented by the following formula is confirmed:

$$[b_{m-r+1}\ b_{m-r+2}\ \cdots\ b_m] = [b_{m-r+1}'\ b_{m-r+2}'\ \cdots\ b_m']$$

Hence, the following formulas are satisfied:

$$C_m^{\#} = C_m + [b_{m-r+1}\ b_{m-r+2}\ \cdots\ b_m]$$
$$(C_m')^{\#} = C_m' + [b_{m-r+1}'\ b_{m-r+2}'\ \cdots\ b_m']$$

From these formulas, the following is obtained:

$$C_m^{\#} = (C_m')^{\#}$$

In view of the above, it is understood that the conditions under which data collision occurs are represented by the following four conditions:

$$A_{m-r} = A_{m-r}' \quad \cdots (11)$$
$$C_{m-r}^{\#} + B_{m-r+1} = (C_{m-r}')^{\#} + B_{m-r+1}' \quad \cdots (12)$$
$$C_{m-r+1}^{\#} + B_{m-r+2} = (C_{m-r+1}')^{\#} + B_{m-r+2}' \quad \cdots (13)$$
$$\cdots$$
$$C_{m-1}^{\#} + B_m = (C_{m-1}')^{\#} + B_m' \quad \cdots (1r)$$

The condition for satisfying formula (11) will be considered. Since an algorithm changes in accordance with the trellis structure of a limited length ($v_0=nv$), the condition for satisfying formula (11) is the time when the following three formulas (21)-(2v) are satisfied simultaneously:

$$[C_{m-r-v+1}]_n = [C_{m-r-v+1}']_n \quad \ldots (21)$$

$$[C_{m-r-v+2}]_n = [C_{m-r-v+2}']_n \quad \ldots (22)$$

$$\ldots$$

$$[C_{m-r}]_n = [C_{m-r}']_n \quad \ldots (2v)$$

Specifically:

$$[A_{m-r-v}\ (C_{m-r-v}^{\#} + B_{m-r-v+1})]_n = [A_{m-r-v}'\ \{(C_{m-r-v}')^{\#} + B_{m-r-v+1}'\}]_n \quad \ldots (31)$$

$$[A_{m-r-v+1}\ (C_{m-r-v+1}^{\#} + B_{m-r-v+2})]_n = [A_{m-r-v+1}'\ \{(C_{m-r-v+1}')^{\#} + B_{m-r-v+2}'\}]_n \quad \ldots (32)$$

$$\ldots$$

$$[A_{m-r-1}\ (C_{m-r-1}^{\#} + B_{m-r})]_n = [A_{m-r-1}'\ \{(C_{m-r-1}')^{\#} + B_{m-r}'\}]_n \quad \ldots (3v)$$

Assuming that the values up to the values of A_{m-r-v}' and $(C_{m-r-v}')^{\#}$ are known values, a description will be given as to how the values of $B_{m-r-v+1}'$ to B_{m-r}' that are factors of M' are determined.

First, the value of $B_{m-r-v+1}'$ is determined in such a manner as to satisfy formula (31). (It should be noted that the value of $B_{m-r-v+1}'$ cannot be determined without reference to the other values.) When the value of $B_{m-r-v+1}'$ is determined, values are determined in the order of $C_{m-r-v+1}' \rightarrow A_{m-r-v+1}' \rightarrow (C_{m-r-v+1}')^{\#}$, in accordance with the following formula:

$$C_{m-r-v+1}' = A_{m-r-v}' \{(C_{m-r-v}')^{\#} + B_{m-r-v+1}'\}$$
$$A_{m-r-v+1}' = g(A_{m-r-v}', [C_{m-r-v+1}']_n)$$
$$(C_{m-r-v+1}')^{\#} = C_{m-r-v+1}' + [\ldots\ldots b_{m-r-v+1}']$$

The portion "......" included in the $[\ldots\ldots b_{m-r-v+1}']$ is specifically $[\ldots\ldots b_{m-r-v+1}' b_{m-r-v}']$ and is a value determined dependent on the past history of the algorithm "... → $A_{m-r-v-1}$ → A_{m-r-v}'". Since the value represented by

$$(C_{m-r-v}')^{\#} = C_{m-r-v}' + [\ldots\ldots b_{m-r-v-1}'\ b_{m-r-v}']$$

is a known value because of assumption, the value of the portion "......" included in the $[\ldots\ldots b_{m-r-v+1}']$ can be regarded as being determinate. Therefore, if it is assumed that the values up to the value of $(C_{m-r-v}')^{\#}$ are known, the value of $(C_{m-r-v+1}')^{\#}$ can be regarded as being determined based only on $B_{m-r-v+1}'$. After similar procedures are repeated, the value of B_{m-r}' is determined in such a manner as to satisfy formula (3v). As a result, values are determined in the order of $C_{m-r}' \rightarrow A_{m-r}' \rightarrow (C_{m-r}')^{\#}$.

It should be noted that the value of $(C_{m-r}')^{\#}$ is dependent on the value of $B_{m-r-v+1}'$ determined at the beginning.

When the values up to the value of $(C_{m-r}')^{\#}$ have been determined, consideration can be made in relation to formulas (1l) to (1r) indicated above. That is, if it is assumed that the values up to the values of

A_{m-r-v}' and $(C_{m-r-v}')^{\#}$ are known, the formulas below are satisfied and data collision occurs:

$$[A_{m-r-v} (C_{m-r-v}^{\#} + B_{m-r-v+1})]n = [A_{m-r-v}' ((C_{m-r-v}')^{\#} + B_{m-r-v+1}')]n \quad \ldots (41)$$

$$[A_{m-r-v+1} (C_{m-r-v+1}^{\#} + B_{m-r-v+2})]n = [A_{m-r-v+1}' ((C_{m-r-v+1}')^{\#} + B_{m-r-v+2}')]n \quad \ldots (42)$$

$$\ldots$$

$$[A_{m-r-1} (C_{m-r-1}^{\#} + B_{m-r})]n = [A_{m-r-1}' ((C_{m-r-1}')^{\#} + B_{m-r}')]n \quad \ldots (4v)$$

$$C_{m-r}^{\#} + B_{m-r+1} = (C_{m-r}')^{\#} + B_{m-r+1}' \quad \ldots (51)$$

$$C_{m-r+1}^{\#} + B_{m-r+2} = (C_{m-r+1}')^{\#} + B_{m-r-+2}' \quad \ldots (52)$$

$$\ldots$$

$$C_{m-1}^{\#} + B_m = (C_{m-1}')^{\#} + B_m' \quad \ldots (5r)$$

The satisfaction of these formulas is one of the sufficient conditions under which data collision occurs. In comparison with the CBC mode of data encryption, the above-noted condition under which data collision occurs is very strict. The number of the formulas representing the condition is (v+r), and it should be noted that the condition is expressed by not only the parameter v which controls the number of encryption algorithms but also the parameter r which is dependent on the history length of the encryption algorithm related to the concealment of encrypted data. In other words, the advantages of the above-noted condition is more than the advantages obtained by merely using a number of encryption algorithms.

As can be seen from the above detailed descriptions, the present invention is featured in two points. First, a plurality of encryption algorithms selectively used by the encryption processing circuits are not switched from one to another in response to a deterministic control signal; they are switched from one to another in a statistic method dependent on the result of the preceding encryption processing circuit. Second, the value obtained by the present-time encryption processing is concealed by use of a value or values dependent on the entirety or part of the past history of encryption algorithms before it is supplied to the next encryption processing circuit, to thereby leave no data suggestive of the control under which an encryption algorithm is changed.

Because of these features, it is practically impossible for a third party to know a series of encryption algorithms actually used in the hashing processing. In addition, since encrypted data is concealed by use of a value or values dependent on the entirety or part of the past history of the encryption algorithms, it is very difficult to prepare message data whose hash value coincides with that of the message data encrypted by the present invention.

In the embodiment mentioned above, the encryption processing circuit can be grouped into blocks such that each block is made by one encryption processing module. If, in this case, each encryption processing module is designed such that it executes both the determination of a new encryption algorithm to be used in the next module and the concealment of the data encrypted by the present-used encryption algorithm, the apparatus incorporating such modules can ensure very reliable data security.

Since the encryption processing circuits are the same in configuration, the adder 1, encryption processor 2, mask processor 3, mask controller 4, and algorithm selection controller 5 of one processing circuit may be fabricated as one module, and this module may be repeatedly used for data blocks B_1 to B_m, as shown in Fig. 5. If this is done, the entire apparatus can be considerably simplified.

In the case shown in Fig. 5, the block processing section 11 divides message data B into data blocks B_1 to B_m and supplies the data blocks B_1 to B_m to the adder 1 on the time divisional basis. The processing result $C_i^{\#}$ of the mask processor 3 is fed back to the adder 1, and a selection signal S produced by the algorithm selection controller 5 is supplied to the encryption processor 2, so as to determine the encryption algorithm to be used subsequently.

Further, an output controller 6 is provided. When the mask processor 3 produces the processing output $C_m^{\#}$

corresponding to the last data block B_m, the output controller 6 outputs the processing output $C_m{}^\#$ as a compressed and encrypted processing result. With this data processing, the apparatus can be very simple in configuration and yet the same operation similar as that of the case shown in Fig. 1 can be realized.

The technique for processing data by selectively using a plurality of function algorithms is not limited to the encryption processing described above; it is applicable to various kinds of data conversion. Fig. 6 shows an example of a general-purpose data processing module which can be applied not only to the data processing apparatuses shown in Fig. 1 and 5 but also to other types of data processors.

Referring to Fig. 6, a function processor 21 stores N function algorithms F_0 to F_{N-1}. The function algorithm executed by the function processor 21 is determined in response to a selection signal supplied from an algorithm selection controller 22. When function algorithm F_k is selected, the function processor 21 carries out calculation $F_k(X)=Y$ with respect to input data X.

The function algorithm selection controller 22 receives the result of the calculation $F_k(X)=Y$ performed by the function processor 21. On the basis of the entirety or part of the received result, the function algorithm selection controller 22 determines function algorithm F_{k+1} to be subsequently executed by the function processor 21, and supplies a selection signal S to the function processor 21.

As described above, the function algorithm can be changed from F_k to F_{k+1} in a variety of methods, and one of such methods is a statistic method wherein the temporal changes in the encryption algorithm are regarded as forming a finite-state discrete-time Markovian process. Needless to say, the function algorithm may be changed deterministically on the basis of calculation result Y.

According to the above configuration, the function algorithm to be used next is determined on the basis of the result of calculation performed by the function processor 21, and this determination process is carried out within the module. Therefore, a third party cannot understand which algorithm is being executed at each stage of the processing.

As indicated by the dotted lines in Fig. 6, the function algorithm may be changed in response to externally-input data X'. In this case, the algorithm selection controller 22 compares the calculation result $F_k(X)$ of the function processor 21 with the externally-input data X', and determines the next function algorithm F_{k+1} on the basis of the comparison. The function algorithm can be changed deterministically or statistically in this modification as well.

When putting the above modification into practice, the following control may be available. That is, when the comparison shows that $F_k(X)$ is equal to X', the present algorithm F_k is maintained unchanged, and when the comparison shows that $F_k(X)$ differs from X', the present algorithm F_k is changed to another algorithm F_{k+1}.

According to the above configuration, the function algorithm is not designated directly by the externally-input data X'. Therefore, a third party cannot know the processing performed inside the apparatus even when the function algorithm is externally selected or controlled.

In the embodiment shown in Fig. 6, the result of the calculation $F_k(X)=Y$ performed by the function processor 21 is not output as it is. In other words, it is masked in an output converter 23 by replacing it with other values, before it is output. Therefore, further reliable data security is ensured.

In the present invention, various data masking methods are available. In the case where the temporal changes in the algorithm form a finite-state discrete-time Markovian process, a method which uses a value B_j ($j \leq k$) dependent on the history of the algorithms executed so far is applicable. That is, value Y is changed by use of the value B_j as follows: $Y'=Y+B_j$ ($j \leq k$).

In the embodiment shown in Fig. 6, a mask controller 24 identifies the history of the past algorithms on the basis of the calculation result Y of the function processor 21, and calculates a value B_j dependent on the history. With this value $_j$ supplied to the output converter 23, the masking processing mentioned above is performed.

Needless to say, the output conversion need not be performed by the mask controller 24. It may be carried out on the basis of fixed data stored in the output converter 23. In addition, if the function processor 21 is made to store data on the history of the function algorithm, the mask controller 24 may receive the history data directly from the function processor 21, as indicated by the dotted lines in Fig. 6.

The above embodiment was described, referring to the case where the function algorithms stored in the function processor 21 are independent of one another. However, this in no way limits the present invention. For example, one function algorithm may be a combination of one fundamental algorithm portion F and a plurality of sub algorithm portions G_0 to G_{N-1}, and the entire algorithm may be changed by controlling only the sub algorithm portions G_0 to G_{N-1}. If this is performed, the function processor 21 need not have a large storage capacity to store the function algorithm, so that a reduction in the circuit scale can be attained easily, as in the case where the module is fabricated as a large scale integrated circuit.

In the above embodiment, the function processor 21 has only one input terminal. However, the present invention is not limited to this. As is indicated by the broken line in Fig. 6, an output of the output converter 23 may be fed back to the function processor 21.

The entire module need not be fabricated as a large scale integrated circuit. In other words, the function processor 21 may be divided into an algorithm storage section and an arithmetic processing section. In this case, an algorithm is read out from the algorithm storage section in response to a selection control signal supplied from the algorithm selection controller 22, and the readout algorithm is supplied to the arithmetic processing section. If the algorithm storage section designed such that the algorithms therein can be varied or a new algorithm can be to added thereto, then data security can be made further reliable, and the range of application of the embodiment can be widened.

Where the data processing module mentioned above is applied to the data processing apparatus shown in Fig. 5, the function processor 21 can be used as encryption processor 2; the algorithm selection controller 22, as algorithm selection controller 5; the output converter 23, as mask processor 3; and the mask controller 24, as mask controller 4. The data processing module is also applicable to the data processing apparatus shown in Fig. 1 in a similar manner.

The present invention is not limited to the embodiments described above. For example, the function algorithms are not limited to encryption algorithms mentioned above; they may be algorithms which are used for other kinds of data conversion. When the present invention is reduced to practice, it can be modified in various manners without departing from the spirit of the invention.

CLAIMS:

1. A data processing module comprising:

a function processor for storing a plurality of function algorithms therein and for executing a designated one of the function algorithms to perform function operation processing; and

an algorithm selection controller for designating a function algorithm to be subsequently executed on the basis of a processing result obtained by the function processor.

2. A data processing module according to claim 1, wherein said algorithm selection controller controls a change in the function algorithms of the function processor by using a statistic method which is based on the entirety or part of the processing result (Y) obtained from a presently-executed function algorithm.

3. A data processing module according to claim 1, wherein said algorithm selection controller controls a change in the function algorithms of the function processor by using a deterministic method which is based on the entirety or part of the processing result obtained from a presently-executed function algorithm.

4. A data processing module according to claim 1, wherein said algorithm selection controller performs comparison between the processing result obtained by the function processor and externally-input data, and designates a subsequently-executed function algorithm on the basis of

the comparison.

5. A data processing module according to claim 4, wherein said algorithm selection controller controls a change in the function algorithms of the function processor by using a statistic method which is based on the comparison between the processing result obtained from the presently-executed function algorithm and the externally-input data.

6. A data processing module according to claim 4, wherein said algorithm selection controller controls a change in the function algorithms of the function processor by using a deterministic method which is based on the comparison between the processing result obtained from the presently-executed function algorithm and the externally-input data.

7. A data processing module according to claim 1, further comprising an output converter for outputting the processing result obtained by the function processor after replacing the processing result with another value.

8. A data processing module according to claim 7, further comprising an output conversion controller for controlling conversion performed by the output converter by using a value which is based on the entirety or part of a history of the function algorithms executed by the function processor.

9. A data processing module according to claim 7, wherein said output converter performs output conversion on the basis of fixed data stored therein.

10. A data processing module according to claim 1, wherein each of said function algorithms stored in the function processor is a combination of one fundamental algorithm portion and a plurality of sub algorithm portions.

11. A data processing apparatus, substantially as hereinbefore described with reference to the accompanying drawings.

The Patent Office

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Claims searched:	1-11	**Date of search:**	12 January 1996

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Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): G4A APB APX

Int Cl (Ed.6): G06F 9/32 9/46 15/18 ; H03M 7/30

Other: On-line : WPI, INSPEC, COMPUTER

Documents considered to be relevant:

Category	Identity of document and relevant passage			Relevant to claims
X	GB-2175112-A	HITACHI	See whole document	1,3,4,6
X	GB-2168508-A	HITACHI	See whole document	1,3,4,6,10
X	EP-0299711-A2	MITSUBISHI	See whole document	1,3,4,6,7
X	EP-0168054-A2	HITACHI	N.b. pages 1-11	1,3
X	EP-0162929-A1	FUJITSU	See whole document	1,3,4,6,10

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